THERMOREGULATION IN ADULT SEABIRDS

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INTRODUCTION

In simple terms, an animal is fit in an evolutionary sense, if it can reproduce, obtain food, and avoid becoming someone else's food. Those animals leaving the most viable offspring at the least possible cost can be considered the most fit. In birds, a major portion of the cost of survival is spent in maintaining a relatively high (38-42°C) body temperature (homeothermy). The maintenance of a relatively constant body temperature is based on a balance between heat production (metabolism), heat transfer from the environment, and heat transfer to the environment. The influence of the environment on homeothermy can best be expressed by the following heat balance equation:

\[ \Delta T_b = R_s \pm R \pm C \pm K \pm MR - E + S \]  

where

- \( \Delta T_b \) = change in body temperature
- \( R_s \) = heat gain from direct solar radiation
- \( R \) = heat gain or loss from thermal radiation
- \( C \) = heat gain or loss from thermal convection
- \( K \) = heat gain or loss from conduction
- \( MR \) = heat gain from metabolism
- \( E \) = heat loss from evaporation
- \( S \) = heat storage

Marine birds, though studied little when compared to other
species, are an excellent group of organisms to study thermoregulation in for the following reasons. Except for the penguins, Ratites, and Procellariiformes (Boyd and Slader, 1971; Warham, 1971) they show little adaptation in body temperature being good homeotherms (Tb between 38-40°C). They vary in size from British Storm Petrel (Hydrobates pelagicus)(0.028 Kg)(Lockley, 1983) to the Emperor Penguin (Aptenodytes forsteri)(26-38 Kg, Pinshow et al., 1974; Le Maho et al., 1976). Their distribution is worldwide, thus they are exposed to the extremes of temperature on earth (Maher, 1962; Bartholomew, 1966; Stonehouse, 1967; Howell et al., 1974).

Even more important to understanding the mechanism of thermoregulation is that within a single genus or group they are exposed to wide environmental variations. Though most of the species within the genus Larus are temperate or boreal, there are a few species breeding in deserts where the daily air temperatures range from 0-40°C (Howell et al., 1974; Bartholomew and Dawson, 1979). Also, penguins breed from the Antarctic to the tropics (Stonehouse, 1967). That seabirds spend a good deal of time in the water stresses the thermoregulatory mechanism even more, water being such a good conductor of heat (24 times that of air). Microclimate conditions on the nesting sites when the birds are tied to land are often extremely demanding, with extreme substratum temperatures, intense solar radiation, and high wind speeds (Stonehouse, 1967; Howell et al., 1974; MacMillen et al., 1977; Lustick et al., 1978; Bartholomew and Dawson, 1979).

In general, seabirds are relatively well-insulated (feather and fat) and seem to tolerate cold better than heat. All birds can tolerate some hypothermia (Dawson and Hudson, 1970), but heat defenses are important because birds regulate their body temperatures (Tb) close to the upper lethal body temperature. Herring Gulls (Larus argentatus) can maintain body temperatures at air temperatures (Ta's) as low as minus 50°C in the absence of wind, whereas they were heat stressed at 3-5°C when exposed to intense solar radiation at wind speeds under 3 m/sec on the nesting grounds (Lustick et al., 1978). The Adelie penguins on Cape Royds pant at air temperatures of -4°C when exposed to full sun during incubation (Stonehouse, 1967).

The Sooty Tern (Sterna fuscata), a small bird (0.15 Kg) nesting in the tropics, has a lower critical temperature of 30°C (MacMillen et al., 1977). Yet at air temperatures of 10°C its metabolism is only twice that of what it was at 30°C. Assuming that birds can increase their metabolic rate 3 to 5 times what it is in thermal neutrality by shivering thermogenesis (Dawson and Hudson, 1970), the Sooty Tern could maintain Tb to at least minus 30°C.

Birds respond to their thermal environment in three ways. There is a morphological response, a physiological response, and a behavioral response. Together they lead to thermal homeostasis.